

REMARKS

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended claims 1 and 3, as well as claims dependent thereon, to recite a method for cleaning a plasma processing apparatus, rather than a method for cleaning processing the plasma processing apparatus. Applicants have further amended claim 1 to recite that while the Si wafer is mounted on the electrode, a mixed gas of hydrobromic gas and chlorine gas is introduced into the processing chamber and a plasma generated. Claim 3 has been further amended to recite that the plasma generated contains the chlorine gas and hydrobromic gas, and “additionally” an element that reacts with fluorine. In connection with amendments to claims 1 and 3, note, for example, pages 13 and 14 of Applicants’ specification; see also, for example, Embodiment 6 on pages 28 and 29 of Applicants’ specification.

The rejection of claims under the second paragraph of 35 USC 112, as being indefinite, set forth in Item 2 on page 2 of the Office Action dated June 28, 2007, is noted. The word “processing” has been deleted from the phrase “cleaning processing”, so that all claims now recite a method for cleaning a plasma processing apparatus having specified structure. In view of this amendment to the claims, it is respectfully submitted that the rejection under the second paragraph of 35 USC 112 is moot.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action dated June 28, 2007, that is, the teachings of U.S. Patent No. 4,786,352 to Benzing, and Japanese

Patent Documents No. 09-171999, No. 2000-012515, No. 11-186226, No. 2001-308068, No. 07-130706, and No. 09-186143, under the provisions of 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a method for cleaning a plasma processing apparatus as in the present claims, the method comprising mounting a Si wafer on an electrode for holding the object to be processed, and while the Si wafer is mounted on the electrode, introducing a mixed gas of hydrobromic gas and chlorine gas into the processing chamber and generating plasma, with aluminum fluoride deposit adhered to the interior of the processing chamber being removed by applying high-frequency power to the Si wafer. See claim 1.

In addition, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a method for cleaning a plasma processing apparatus as in the present claims, including providing a cleaning period by generating plasma containing chlorine gas and hydrobromic gas and additionally an element that reacts with fluorine to create a gas phase reaction product. See claim 3.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such methods for cleaning as in the present claims, having features as in claims 1 and 3 as discussed previously, and, additionally, wherein the process further includes placing a Si wafer, with no patterns printed thereon, on the substrate holder when the plasma including chlorine gas and hydrobromic gas is discharged, with high-frequency power being applied to the Si wafer (see claims 8 and 9), in particular, wherein the high-frequency power corresponds to a frequency of 400 kHz and is

equal to or greater than 0.11 W per unit area of the wafer (see claim 9); and/or wherein a ratio of an area of an earth to the area of an inner wall of the vacuum container in contact with the plasma is 40% or more (see claim 10); and/or the additional gas supplied simultaneously with the chlorine and hydrobromic gasses, as in claim 13; and/or wherein the plasma containing the chlorine and hydrobromic gasses additionally contains Si, to create the gas phase reaction product (see claim 15); and/or wherein a portion of material constituting the vacuum container includes Si, as in claim 16; and/or wherein the plasma containing chlorine and hydrobromic gasses additionally contains SiCl_4 gas (see claim 17).

Moreover, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such cleaning method as in the present claims, having features as discussed previously in connection with claim 3, and further including a period for generating plasma containing SF_6 prior to the period for generating plasma with the chlorine and hydrobromic gasses. See claim 14.

The present invention relates to a method for cleaning a plasma processing apparatus, particularly useful in connection with cleaning a vacuum chamber having an aluminum fluoride deposit therein. Such deposit can cause problems if not cleaned, in that such deposit builds up and can affect the plasma, and can also flake off and deposit on the substrate being processed, causing defective products and thus undesirably reducing yield.

It has been known that when a gas containing fluorine is used during plasma processing, aluminum fluoride is generated, which is a stable compound having low vapor pressure and which cannot be removed easily. Various methods for removing aluminum fluoride have been proposed. One method uses Cl_2 gas to decompose

AlF_3 into AlCl_3 , and another method proposed decomposing and removing AlF_3 using H_2O and Cl_2 . As for these previously proposed cleaning methods, note the paragraph bridging pages 5 and 6 of Applicants' specification.

However, recently materials of the wafers, and gasses used in the plasma processing, have diversified, and the problem of deposits that cannot be removed by conventional plasma cleaning methods has become more significant. Note the last full paragraph on page 6 of Applicants' specification. Therefore, a more effective method for cleaning the reaction chamber is required, for enhancing throughput.

Against this background, Applicants provide a method wherein contaminants, such as deposits, in particular, deposits of aluminum fluoride, in the vacuum processing chamber, can be safely and effectively removed, in a short time, thereby avoiding reductions in throughput. Applicants have found that by forming a plasma including a mixed gas of hydrobromic gas and chlorine gas, in apparatus in which a silicon wafer is placed on an electrode for holding the object to be processed, and with a high frequency power applied to the Si wafer; and/or wherein the plasma generated additionally includes an element that reacts with fluorine to create a gas-phase reaction product, such plasma can be used to remove aluminum fluoride deposits adhered to the interior of the processing chamber, effectively and in a short time. Note especially Embodiment 1 on pages 9-14 of Applicants' specification.

Applicants have found that by including, e.g., Si in the plasma containing chlorine gas and hydrobromic gas, a further improvement of speed in removing aluminum fluoride is achieved. Note Embodiment 4 on pages 22-27 of Applicants' specification. Note especially Table 1 on page 23, and the discussion in connection therewith in the paragraph bridging pages 23 and 24, of Applicants' specification; see also Embodiment 2 on pages 16 and 17.

In addition, Applicants have found that with various processing, carbon deposits may occur in the processing chamber; and that such carbon deposits can be removed effectively and efficiently, by generating plasma containing SF₆ prior to generating the plasma containing the chlorine and hydrobromic gasses, and additionally the element that reacts with fluorine (e.g., Si). See, e.g., the first full paragraph on page 27 of Applicants' specification.

Japanese Patent Document No. 09-171999 discloses a plasma cleaning treatment, subsequent to etching, with a mixed gas plasma of BCl₃ and Cl₂, a laminated structure film which uses an organic film and which contains, inter alia, a barrier metal. This patent document discloses that in order to remove the reaction product of the etching treatment, the inside of the etching treatment chamber is plasma-treated with H₂O gas, and then the inside of the etching treatment chamber is plasma-treated with a gas containing chlorine. After that, the inside of the etching treatment chamber is plasma-treated additionally with O₂ gas.

Japanese Patent Document No. 2000-012515 discloses a plasma cleaning method for plasma etching apparatus, wherein the etching chamber is cleaned using a mixed gas of BCl₃ and Cl₂.

Japanese Patent Document No. 11-186226 discloses a plasma cleaning method in a plasma processor, including a cleaning step with an oxygen gas plasma and a cleaning step with a mixed gas plasma of Cl₂ and BCl₃.

It is respectfully submitted that each of the primary references as applied by the Examiner in Item 4 of the Office Action dated June 28, 2007, would have neither disclosed nor would have suggested such method as in the present claims, including the specific mixture of gasses as in claims 1 and 3, or wherein a Si wafer is mounted on an electrode, and while the Si wafer is mounted on the electrode the mixed gas is

introduced and plasma generated, with removal of aluminum fluoride deposit by applying the high-frequency power to the Si wafer, as in claim 1; or wherein the plasma generated contains in addition to chlorine and hydrobromic gasses, additionally an element that reacts with fluorine (e.g., Si), as in claim 3; and advantages thereof; and/or other features of the present invention as discussed in the foregoing, and advantages thereof.

It is emphasized that according to aspects of the present invention, an element that reacts with fluorine is included in addition to chlorine and hydrobromic gasses, further improving speed in removing aluminum fluoride.

It is respectfully submitted that the additional teachings of the references applied by the Examiner in Item 4 on page 2 of the Office Action dated June 28, 2007, would not have rectified the deficiencies of any one of the primary references, such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Thus, Japanese Patent Document No. 07-130706 discloses a cleaning technique for removing a reaction product even in a vacuum state of a reactive chamber. When cleaning is carried out, a Cl_2 gas is supplied to a reactive chamber, and plasma is generated with the Cl_2 at a high-frequency voltage. This patent document discloses that the reaction product is changed into an AlCl_3 gas that has a high vapor pressure, which is vaporized easily and discharged easily through a discharge pipe 20.

Japanese Patent Document No. 2001-308068 discloses a method of cleaning, for removing AlF_3 deposited on an inner wall of a chamber of an etching process, the method including a first step of performing H_2O plasma processing, and, following

the first step, a second step of performing Cl_2 plasma processing, after executing an Al dry etching process.

Even assuming, arguendo, that the teachings of either of No. 07-130706 or No. 2001-308068 were combined with the teachings of the primary references, such combined teachings would have neither disclosed nor would have suggested the specific combination of chlorine and hydrobromic gasses as in the present claims, or mounting a Si wafer on an electrode for holding the object to be processed and introducing the mixed gas while the Si wafer is mounted on the electrode, with the aluminum fluoride deposit removed by applying the high-frequency power to the Si wafer, as in claim 1; and/or wherein the plasma containing chlorine and hydrobromic gasses additionally contains an element that reacts with fluorine, as in claim 3; and/or the other features of the present invention as recited in the dependent claims, and discussed previously, and advantages thereof.

It respectfully submitted that the additional teachings of Benzing would not have rectified the deficiencies of the teachings of the other references as applied by the Examiner in Item 4 on page 2 of the Office Action dated June 28, 2007, so as to render the presently claimed subject matter obvious under the requirements of 35 USC 103.

Benzing discloses cleaning devices used to remove deposits and/or contamination from processing chamber walls, tooling and substrates within such chambers, the device and method including two or more electrodes that may be shaped as interleaving fingers and that are fixtured on the exterior of a process chamber that is constructed primarily of dielectric material, RF power and ground potential being coupled to the electrodes. This patent discloses that by evacuating the chamber, admitting a cleaning gas and applying RF potential, a plasma is formed

within the chamber; and by appropriate choice of the cleaning gas and configuration of the electrodes, either the interior walls of the chamber together with any tooling can be cleaned or the surfaces of substrates placed within the chamber can be cleaned. See the paragraph bridging columns 1 and 2 of this patent. Note also column 3, lines 41-49. See, further, column 4, lines 32-42, describing that the cleaning gas may be such known gasses as CF_4 , CF_4 and O_2 , C_2F_6 , SF_6 or NF_3 ; and note also column 5, lines 25-36, describing that other cleaning gasses that yield a specie upon decomposition in a plasma which, upon reaction with the chamber wall deposits and/or contaminants, yields a volatile product, may also used, such as CF_3Cl , CF_3Br , CCl_4 , BCl_3 , Cl_2 , HCl , HBr , O_2 or various combinations of the preceding gasses with themselves and/or inert gasses. Referring to column 4, lines 32-39, and with reference to Figs. 2 and 3, this patent discloses that for chamber cleaning, substrates 12 are removed from the quartz tube 14 and the base plate 18 is affixed to the front of the tube 14, making a vacuum tight seal, with cleaning gas being introduced into the tube 14.

It is emphasized that according to Benzing the wafers are removed from the quartz tube for chamber cleaning. Even assuming, arguendo, that the teachings of Benzing would have directed one of ordinary skill in the art to introducing a mixed gas of hydrobromic gas and chlorine gas during cleaning, the teachings of Benzing as a whole, together with the teachings of the other applied references, would have neither disclosed nor would have suggested, and in fact would have taught away from, mounting a Si wafer on an electrode for holding the object to be processed, and, while the Si wafer is mounted on the electrode, the mixed gas is introduced into the processing chamber and plasma generated, and an aluminum fluoride deposit is removed by applying the high-frequency power to the Si wafer.

Furthermore, it is respectfully submitted that the disclosure of Benzing, even in combination with the teachings of the other applied references, would have neither disclosed nor would have suggested cleaning the aluminum fluoride deposit in the vacuum container by generating plasma containing, in addition to chlorine and hydrobromic gasses, an element that reacts with fluorine (e.g., Si) to create a gas-phase reaction product, and advantages thereof as discussed in the foregoing.

The comments by the Examiner in Item 5 on page 3 of the Office Action dated June 28, 2007, are noted. Even assuming, arguendo, that the Examiner is correct in interpretation of the teachings of the applied references, such disclosures would have neither taught nor would have suggested the presently claimed subject matter, including the introduction of the mixed gas and generating plasma while the Si wafer is mounted on the electrode, with removal of aluminum fluoride by applying the high-frequency power to the Si wafer; or wherein the plasma containing chlorine and hydrobromic gasses additionally contains an element that reacts with fluorine to create a gas-phase reaction product; and/or other features of the present invention as discussed previously, and advantages thereof.

It is noted that the Examiner has rejected claims 1-4 and 6-14 over the combined teachings of references as set forth in Item 4 on page 2 of the Office Action dated June 28, 2007. Note, however, that claims 2, 4, 6, 7, 11 and 12 have previously been cancelled, and that claims 15-17 have not been rejected in this Item 4. If the Examiner maintains this rejection, the Examiner is respectfully requested to review and clarify claims being rejected over the applied references in Item 4 on page 2 of the Office Action dated June 28, 2007.

With respect to the rejection of claims set forth in lines 1-16 on page 4 of the Office Action dated June 28, 2007, Japanese Patent Document No 9-186143

discloses a method of cleaning an internal surface of a plasma chamber, using a mixture of chlorine and fluoride content gas by which oxygen or an atom-like oxygen content does not exist. Note paragraph [0012] of the English translation of No. 9-186143, as well as paragraphs [0018], [0022], [0023] and [0027].

Benzing has been previously been discussed.

Even assuming, arguendo, that the teachings of No. 9-186143 and Benzing were properly combinable, such combined teachings would have neither disclosed nor would have suggested the presently claimed cleaning method, including mounting a Si wafer on an electrode for holding the object to be processed, and while the wafer is mounted on the electrode introducing the mixed gas and generating plasma, with aluminum fluoride deposit removed by applying the high-frequency power to the Si wafer, as part of the presently claimed method; and/or wherein the plasma generated contains chlorine gas and hydrobromic gas and additionally an element that reacts with fluorine, and/or other features of the present invention as discussed previously, and advantages thereof.

Again, it is emphasized that Benzing discloses removal of substrates from the quartz tube for the chamber cleaning, and it is respectfully submitted that the disclosure thereof, even in light of the disclosure of No. 9-186143, would have taught away from aspects of the present invention, including, inter alia, wherein the Si wafer is mounted on the electrode, with the mixed gas being introduced and plasma generated while the Si wafer is mounted on the electrode, and aluminum fluoride deposit removed by applying high-frequency power to the Si wafer, as in claim 1; and/or wherein the plasma containing chlorine and hydrobromic gasses additionally contains an element that reacts with fluorine, as in claim 3; and/or other features of the present invention as discussed previously.

Furthermore, it is respectfully submitted that the teachings of Benzing by itself would have neither disclosed nor would have suggested the presently claimed invention. Again emphasizing that Benzing discloses cleaning with removal of the substrates, it is respectfully submitted that the teachings of Benzing by itself would have taught away from those features of the present invention as in claims 1 and 3, as discussed previously, and advantages thereof; and/or the other features of the present invention as discussed previously, and advantages thereof.

In addition, and especially in connection with claim 1, attention is respectfully directed to Embodiment 4 on pages 22-27 of Applicants' specification, and in particular Table 1 on page 23 thereof. From Table 1, the unexpectedly better results achieved utilizing a mixed gas of hydrobromic gas and chlorine gas, with silicon wafer material on the wafer holder and bias power applied to the wafer, can be seen. Such evidence must be considered in determining patentability. See In re DeBlauwe, 222 USPQ 191 (CAFC 1984). In light of the unexpectedly better results achieved according to the present invention, particularly as set forth in claim 1, shown by the evidence in Applicants' specification, it is respectfully submitted that Applicants have established patentability of the presently claimed subject matter.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the application are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 648.43608X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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